With regards of the author

Issued July 18, 1913.

U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN 543.

EXAMINED

COMMON WHITE GRUBS.

IMP. BUREAU ENTOM.
Recd. 5 FEB 1914
Answd.

BY

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WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1913.

LETTER OF TRANSMITTAL.

UNITED STATES DEPARTMENT OF AGRICULTURE,
BUREAU OF ENTOMOLOGY,
Washington, D. C., April 19, 1913.

SIR: I have the honor to transmit for publication as a Farmers' Bulletin a brief account of the common white grubs.

A thorough study of the white-grub problem throughout the United States has recently been undertaken by the Bureau of Entomology, cooperating with the office of State entomologist of Illinois, and with the further aid of the Indiana Agricultural Experiment Station and Purdue University. As this investigation has only fairly begun, the present publication is in no sense a report, but is merely intended to give a brief summary of the life history and habits of these insects, as now understood, together with the best known means of controlling them. The bulletin has been prepared with special reference to the destructive outbreak of 1912 and the seemingly strong probabilities of a similar infestation in 1915.

This subject is of the greatest importance to farmers, whose cooperation is much needed in carrying out the work and securing practical results therefrom.

Respectfully,

L. O. HOWARD,
Entomologist and Chief of Bureau.

Hon. D. F. HOUSTON,
Secretary of Agriculture.

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COMMON WHITE GRUBS.[1]

The common white grubs (fig. 1), or grubworms, as they are often called, have for years been recognized as among the most serious pests to farm crops, notably corn and timothy, while strawberries, potatoes, and nursery plantings, particularly of conifers, have all been frequently and seriously affected.

These pests have never been given extended economic study, except by Dr. S. A. Forbes,[2] State entomologist of Illinois, to whom we are indebted for nearly all of our practical knowledge of the parent May beetles (fig. 2) and their progeny, the white grubs.

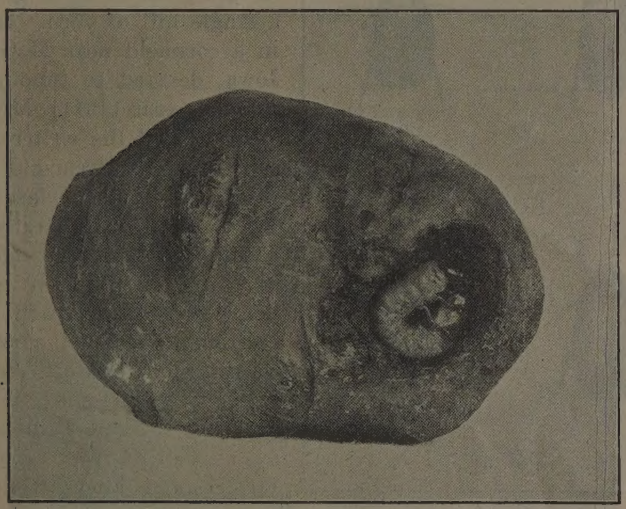

FIG. 1.—White grub working in a potato tuber, Tabor, S. Dak., 1912. (Original.)

THE OUTBREAK OF 1912.

Probably the most serious outbreak of white grubs in the history of American agriculture occurred in 1912, following an abundance of beetles in 1911. Injury was reported from almost every section of the country north of the Ohio River and westward to South Dakota. (See fig. 3.) In the West the center of abundance was in southwestern Wisconsin, while in the East it seemed to be in northeastern Pennsylvania and southeastern New York.

[1] *Lachnosterna* spp.

[2] Insect Life, vol. 3, no. 5, pp. 239–245, 1891; 18th Rept. State Ent. Ill., pp. 109–144, 1894; Ill. Agr. Exp. Sta., Bul. 116, 1907.

Infestation occurred, however, as far west as Tabor, S. Dak., and though no serious general injury was found west of eastern Iowa there were scattered occurrences in western Iowa and southern Minnesota. Throughout the southern third of Wisconsin and in northern Illinois the grubs were abundant, especially in the western portions of those sections. Many infestations were also reported from southern Michigan and scattered ones from northern Indiana and eastward through Ohio. These infestations again became general in northeastern Pennsylvania, southeastern New York, in Connecticut, and in parts of New Jersey.

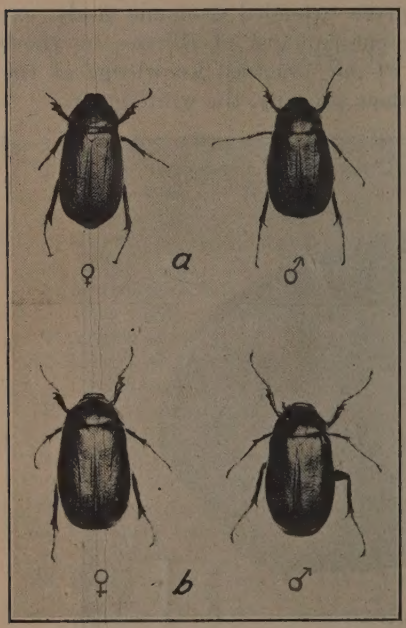

FIG. 2.—Typical examples of May beetles: *a*, *Lachnosterna crenulata*; *b*, *Lachnosterna fusca*. Natural size. (Original.)

In the worst infested districts it was not at all unusual to find from 40 to 60 grubs in a single hill of corn. Indeed, in a cornfield near McGregor, Iowa, devoted to timothy the previous year (1911), Mr. R. L. Webster and the writer found seventy-seven 2-year-old grubs in an area 2½ feet square and 5 inches deep. This really represented less than a single hill of corn, for the hills in this field were 3½ feet apart.

From a personal survey of the infested territory made in 1912 in Iowa (fig. 4), Wisconsin (fig. 5), and Illinois (fig. 6), as well as from reports of farmers and others, we have a very conservative estimate of the damage to corn, timothy, and potatoes in these States, aggregating not less than $7,000,000. The damage to the same crops in the other infested areas can not be figured at less than $5,000,000, which brings the total loss in 1912, exclusive of strawberries, nursery stock, lawns, and miscellaneous crops, to not less than $12,000,000.

POSSIBILITY OF AN OUTBREAK IN 1915.

Available records show that May beetles were unusually abundant in 1908, the grubs causing considerable damage in Wisconsin, Illinois, and other localities in 1909 and again in 1912. The damage, however, was more pronounced in these localities in 1912. As previously noted, the beetles were very abundant in the spring of 1911, thus giving rather conclusive evidence that the life cycle of the more abun-

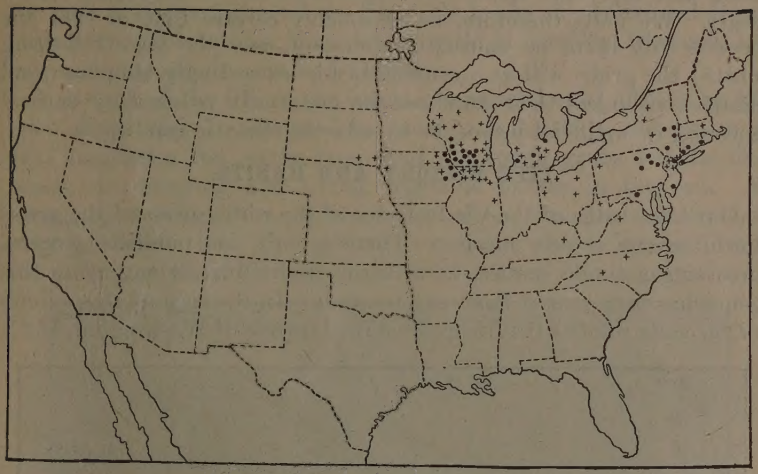

FIG. 3.—Map showing the invasion of white grubs in 1912. (Original.)

FIG. 4.—A 60-acre cornfield completely destroyed by white grubs, Farmersburg, Iowa, 1912. (Original.)

dant and injurious species in those localities is uniformly three years. We may, therefore, be reasonably certain that in 1914 the beetles will again be unusually abundant, and the year following (1915) the grubs will as a consequence be exceedingly abundant and destructive unless their numbers are materially reduced by natural enemies, by artificial means, or by adverse climatic conditions.

LIFE HISTORY AND HABITS.

Our knowledge of the life histories of the white grubs of the genus Lachnosterna is very meager. There is only one published record, involving a single species, in which an individual belonging to this genus has been reared from egg to adult. In the case of this species (*L. arcuata* Smith) the life cycle in the latitude of Washington, D. C.,

FIG. 5.—A cornfield showing characteristic injury by white grubs, Lynxville, Wis., 1912. (Original.)

proved to be three years.[1] From observations reported by Forbes, and from our own observations and rearing experiments, it appears quite certain that in the Northern States the total life cycle of the more injurious species is three years. However, in the case of *L. tristis* Fab., a small species, and one which we have recently reared from egg to adult, the life cycle is only two years. Mr. W. R. Dickeson, of Austin, Tex., writing of the damage by *L. farcta* Lec., says, "One year the grub bothers us and the next year the May beetle," which is circumstantial evidence that this species has only a 2-year cycle in Texas. The total life cycle in all the species occurring in the Southern States may be only one or two years, and in the central

[1] U. S. Dept. Agr., Div. Ent., Bul. 19, n. ser., p. 77, 1899.

parts of Canada it may possibly extend over a period of four years, for such is the variation of the life cycle in the closely related European white grub,[1] which has a 4-year cycle in northern Germany but only a 3-year one in southern Germany.

A résumé of the life of the injurious generation of 1912 is as follows: Eggs (fig. 7) deposited by the female beetle in the spring of 1911 hatched a few weeks later, and the young grubs fed the first season on decaying and living vegetable matter in the soil. As winter approached they protected themselves from the cold by burrowing deeper into the ground, remaining there inactive until the spring of the following year (1912), when they returned to a

FIG. 6.—A cornfield injured by white grubs, Galena, Ill., 1912. (Original.)

position near the surface, feeding on the roots of such crops as were available. In this the second year they did the maximum amount of damage. In the fall they again went deep into the soil, to return near to the surface in the spring of 1913, where they will feed as before on the plant roots until about June. They will then prepare oval pupal cells in the ground, become more or less inactive, and later change to the pupal or true dormant stage. The adult beetles, which will emerge from the pupæ a few weeks later, will remain in the pupal cells over winter and will emerge the following spring (1914) to feed and mate in the foliage of trees and shrubs and to deposit their eggs in the soil for another generation.

[1] *Melolontha vulgaris* L.

Unlike the grubs, the different species when in the beetle stage have as a rule different food preferences. Certain species feed almost exclusively on the oak, others prefer the ash, some feed indiscriminately, etc. The trees which the beetles ordinarily frequent at La Fayette, Ind., are the ash, oak, poplar, elm, willow, locust, soft maple, and hackberry. In certain localities the pine seems to be the preferred food. Mr. H. P. Loding reports that in the vicinity of

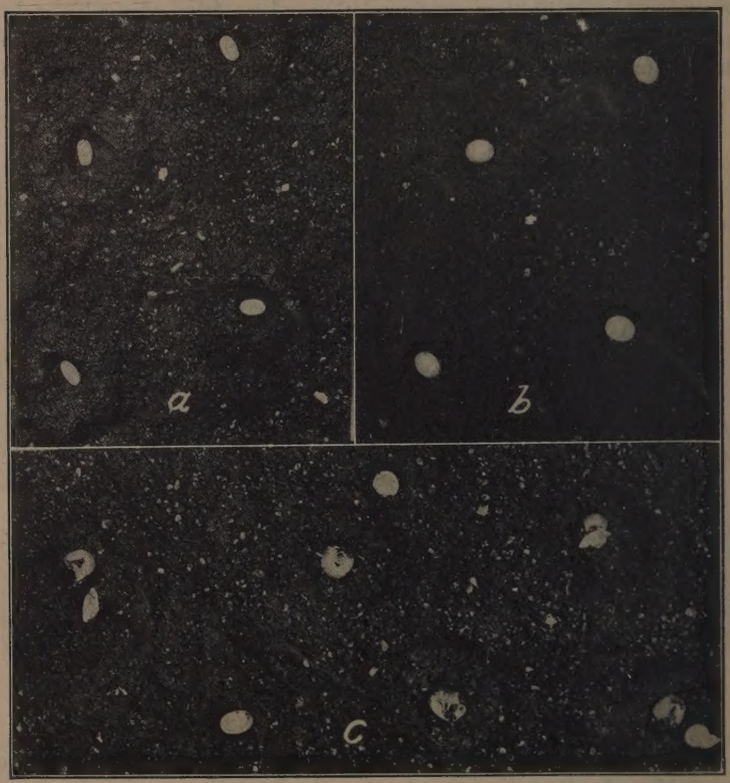

FIG. 7.—Eggs of white grubs in their natural cells: *a*. Immediately after deposition; *b*, six or seven days later; *c*, white grubs hatching. (Original.)

Mobile, Ala., he has collected *L. prununculina* Burm. and *L. micans* Knoch feeding on the longleaf pine, which indeed appears to be their favorite and in some cases possibly their sole food.

In the latitude of Indiana the beetles make their first appearance the last of April or first of May and continue to be present until the first or middle of July, the period of greatest abundance being between the middle and last of May. They swarm to the trees at dusk

and remain there feeding and mating till just before dawn, when they return to the soil, only to reappear the following evening.

When abundant the beetles are capable of defoliating large acreages of timber, often resulting in the death of many of the trees thus attacked. In 1911, 40-acre tracts of timber were completely defoliated by the beetles in southwestern Wisconsin. According to witnesses, the dropping of excrement and of detached leaves at night, when the beetles were feeding, sounded like hail. The following year, 1912, numbers of dead and dying trees were observed in these timber tracts, their death in most cases doubtless resulting from the loss of foliage the year before.

Not only do the different species have individual food preferences, but they also differ in the dates of emergence, some appearing early and remaining throughout the season, others appearing about midseason and remaining only a few weeks. Some species, also, occur only at the higher elevations, while others appear to be common only at the lower levels; but whether this difference is due to a difference of elevation or to the character of the flora, or to a combination of the two, has not as yet been determined.

The beetles (fig. 2) prefer to deposit their eggs in ground covered with vegetation, in the immediate vicinity of timber, usually choosing for this purpose the more elevated parts. For these reasons the grubs are ordinarily found most abundant in the higher portions, especially near wooded tracts, of fields of timothy (fig. 8), blue-grass sod, and small grains, or in any ground which during the previous year was in one or another of these crops.

The eggs (fig. 7, *a*, *b*, *c*) are pearly white and when first laid are elongate, measuring about one-tenth inch in length, but six or seven days after oviposition they become swollen and almost spherical. They are deposited in the soil at a depth ranging from 1 to 8 inches, within oval cavities in the center of balls of earth, the particles of earth forming the balls being held together by a glutinous secretion supplied by the female beetle.

The very young grubs seem to prefer decaying vegetation, although under certain conditions, especially when they are very numerous, they will attack living roots, as was the case in Wisconsin in 1911 when the young grubs damaged timothy fields (fig. 8). As might be expected, the grubs do the greatest amount of damage in their second year and to the early plantings in their third year. While grubs show a preference for certain food plants, from our present data the grubs of different species do not appear necessarily to have different food habits. We have no authentic records of injury to such crops as clover, alfalfa, and buckwheat, and from all observations small grains are less attacked and injured than are corn, timothy, strawberries, and potatoes.

GRUBS LIKELY TO BE MISTAKEN FOR COMMON WHITE GRUBS.

It is important that the grubs of May beetles should not be confused with similar but noninjurious grubs and with such other grubs as may be injurious but which, because of their different habits and life history, necessitate different methods for their control. Probably the most universal mistake is the general belief that the common white grubs of the field and the white grubs found in manure heaps and rotten logs are identical. The grubs of May beetles are not known to breed in manure or refuse of any kind. The most common grubs found in manure are the immature forms of certain brown beetles[1] which, like the May beetles, frequent lights, and would doubtless be mistaken for the latter by an inexperienced person.

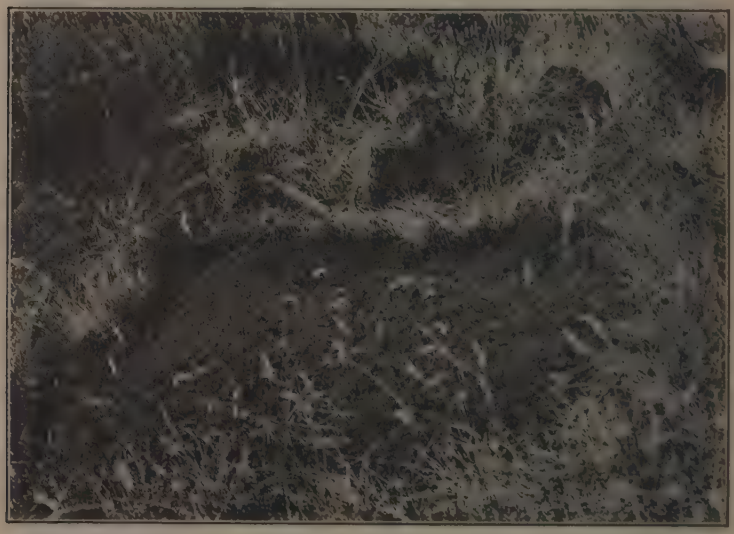

FIG. 8.—A piece of sod overturned to show the white grubs underneath, Lancaster, Wis., 1912. (Original.)

Another grub commonly mistaken for a grub of a May beetle is that of the southern green June beetle,[2] which has frequently been reported as injuring grass and other vegetation in localities south of latitude 39°, or even farther north along the Atlantic coast. The grub of the green June beetle seems to prefer soils more or less heavily fertilized with manures, and besides, entirely unlike the common white grubs, it makes definite burrows which usually open at the surface and which it may inhabit continuously for longer or shorter periods of time. For this reason grubs of this species will come to the entrance of their burrows and even crawl out upon the ground

[1] *Ligyrus gibbosus* De G. and *L. relictus* Say.

[2] *Allorhina nitida* L.

when the land is flooded with water. This characteristic also offers us a satisfactory means of controlling the grub of the green June beetle when in lawns or small areas. (See p. 20.) Again, this grub may be distinguished from the true white grubs by its general appearance, and especially by its peculiar and characteristic method of crawling on its back when placed on the surface of the ground.

NATURAL ENEMIES.

The white grubs and May beetles are preyed upon by numerous birds, mammals, and insects, all of which are more or less useful in reducing their numbers. Probably the most important of these enemies are the birds, especially crows and crow blackbirds. Fields of

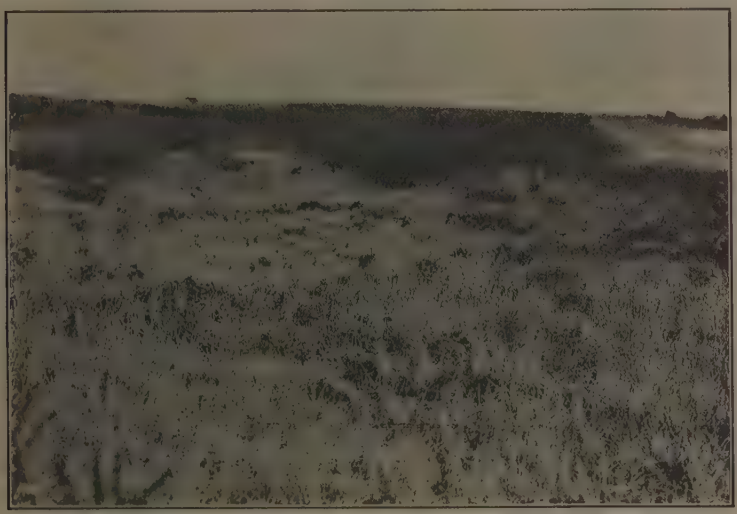

FIG. 9.—Timothy field after harvest, showing sod overturned by crows in their search for white grubs, Galena, Ill., 1912. (Original.)

timothy sod have been literally overturned by crows in their search for grubs (see fig. 9), and in some fields the grubs were almost exterminated by them. Crows have often been observed following the plow in infested fields, eagerly picking up every grub that was unearthed. Mr. Henry Holzinger, of Lancaster, Wis., said that crow blackbirds followed the plow in great numbers where he was turning over a sod field in the spring of 1912. In one instance he watched a single blackbird eat many grubs, apparently its full capacity, and then gather as many as it could hold in its beak and fly away. In this case the bird destroyed in all 20 grubs in about 1 or 2 minutes. This habit of eating a large number of grubs and then flying away with its beak full was reported as a common occurrence with the blackbird. Mr. Fred Nelson, of Tabor, S. Dak.,

stated that his attention was directed to the unusual abundance of grubs in his field in the fall of 1911 by the blackbirds which came in flocks and followed him as he plowed. He soon learned that they were gathering grubs. After picking up several grubs each bird would fly back to the trees a short distance away and soon return. Thus there was a continuous flight from the trees to the ground and from the ground to the trees. Besides crows and blackbirds practically all of our common birds feed on white grubs or their adult forms, the May beetles. The Biological Survey has found these insects in the stomachs of more than 60 species of birds.

Domestic fowls may properly be classed as natural enemies of white grubs, although their usefulness is largely controllable. All farm poultry are fond of these insects, and where possible should be given the run of infested fields at the time of plowing. The turkey especially is valuable in this capacity, and the writer has seen infested timothy and sod fields literally overturned by these birds in their search for grubs.

FIG. 10.—*Pyrgota undata*, a fly parasite of May beetles. Natural size. (Original.)

Among the undomesticated mammals which feed on the grubs the skunk, or so-called polecat, is probably the most valuable,[1] and, indeed, some farmers have gone so far as to attribute the increase in these insects to the decrease in numbers of the skunks, which are being rapidly killed off by trappers. In a field of winter wheat at Lagro, Ind., the grubs were reported cutting off the young wheat plants, and when the fields were examined a few days later (November 3, 1911) a skunk hole 3 to 5 inches in depth was found at nearly every stool of wheat which had been attacked by the grubs, and in every case the animal had invariably captured the culprit. In northeastern Iowa many large landowners observed the grub-eating habits of the skunk during the recent severe outbreak, and have signified their intention from now on of protecting this friend of the farmer. Innumerable instances of this nature illustrating the value of skunks could be cited.

A number of predaceous and parasitic insects have been reported as attacking the grubs and May beetles, and of these enemies it is probable that such common and generally distributed forms as the black digger wasp, *Tiphia inornata* Say, and another wasp, *Elis sexcincta* Fab., both of which attack the grub, together with a fly, *Pyrgota undata* (fig. 10), which attacks the adult beetle, are the most

[1] The domestic hog is the most efficient of all grub destroyers where it can be utilized. It is fully discussed in this connection under "Methods of control," p. 16.

beneficial. The Tiphia larva, after devouring the grub, forms a characteristic cylindrical-ovate, light brown, woolly cocoon about three-fourths inch in length (fig. 11, *b*), and from this the jet black digger wasp emerges the following spring. It in turn mates, and the female reenters the soil and there deposits its eggs on the grub, usually fastening them on the back of the latter just behind the head. The Elis cocoon (fig. 11, *a*) differs from the Tiphia cocoon (fig. 11, *b*) in that it is elliptical, slightly longer, and comparatively smooth. The adult emerging therefrom is about the same size as the Tiphia wasp, or slightly larger, and the black abdomen is transversely striped with yellow. The cocoons of both of these parasites are frequently turned out by the plow, especially in fields badly infested with white grubs. The parasitic fly *Pyrgota undata* Wied.[1] (fig. 10) attacks only the beetle, usually depositing its egg within the body of the beetle as the latter flies from leaf to leaf or to the ground at night. The larvæ hatching from these eggs gradually kill the beetle, although as a rule the latter, if a female, is capable of copulating and of depositing eggs for some days after being parasitized; consequently this parasite may not be so valuable as might at first be anticipated.

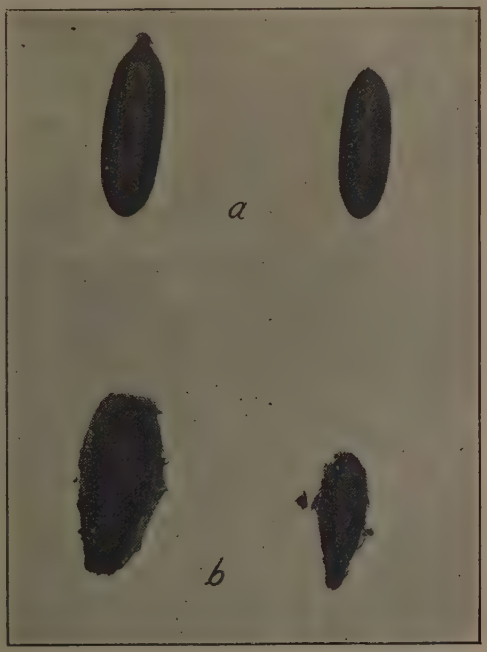

FIG. 11.—Cocoons of wasps that prey on white grubs: *a, Elis sexcincta*: *b, Tiphia inornata*. Natural size. (Original.)

Several fungous and bacterial diseases have been reported attacking the grubs and beetles, but the knowledge of these is as yet superficial. Occasional outbreaks of these diseases have been reported, and it is highly probable that they serve as valuable natural checks. In Europe certain of these diseases have been artificially grown and used to destroy the grub, but there seems to be a divergence of opinion

[1] It has been found that another species of Pyrgota (*P. ralida* Harr.) is parasitic on the beetles, and this species may prove to be equally as important as *P. undata*.

as to their value when used in this manner, and the feasibility of their use for this purpose is still an open question.

METHODS OF CONTROL.

All general measures here discussed and recommended are preventive rather than remedial, for once white grubs are present in a field of corn or other crop there is no means as yet known of protecting that particular crop from its ravages. On the other hand, there are certain cultural and other practices which will greatly minimize the damage in succeeding years.

FIG. 12.—Pasture sod overturned by swine in their search for white grubs, Lancaster, Wis., 1911. (Original.)

UTILIZING HOGS AND POULTRY FOR DESTROYING THE GRUBS.

An infested field may be thoroughly cleared of grubs by pasturing it with hogs, and this method should be followed wherever possible. Hogs are very fond of grubs and will root to a depth of a foot or more in search of them. (See fig. 12.) Such pasturing may be done at any time during the summer, but it should not be delayed later than the middle of October nor should it be practiced earlier in spring than April in the latitude of central Indiana or May in the latitude of Wisconsin, since at other times the grubs will probably be in their winter quarters, deep in the ground, and a large percentage may then escape the hogs.

It should be noted here that the giant thorn-headed worm,[1] an intestinal worm attacking swine, passes one of the early stages of its life within the white grub, and hogs become infested with these worms by feeding on infested grubs. The grubs in turn become infested through the excrement of infested swine. In the grub-infested localities of Iowa, Illinois, and Wisconsin visited by the writer this intestinal worm is quite prevalent, but inasmuch as most of the swine in these regions are slaughtered before they are 1 year old the prevalence of the worms in this region is of little if any importance. Precautions should be taken, however, to protect the animals from infestation where possible. In this connection Dr. S. A. Forbes says:[2]

> Pigs which have never been pastured are certain to be free from these parasites, and grubs growing in fields which have not been pastured by pigs are likewise certain to be free from them. The use of such pigs upon such fields would consequently be without danger from this source, and a little attention to these facts will avoid any injurious consequences. That is, if pigs not previously allowed to run out are turned into fields on which pigs have not been pastured within three years, there will be no danger that they will become infested by these thorn-headed worms.[1]

In 1912 the writer observed a field in which half of the corn was uninjured and free from grubs, while the other half was badly damaged. The previous year both halves of this field had been in timothy, but with this difference: The half where the injury occurred was left for hay and the other half was fenced off and pastured with dairy cows. The only plausible explanation seems to be that the trampling of the ground by the cows killed the eggs and grubs in the field, or else that the ground had been trampled sufficiently previous to the flight of the beetles to prevent them from entering the soil and laying eggs.

Domestic fowls should be given the run of infested fields, and especially when the land is being plowed, for they are very fond of grubs and will destroy large numbers.

During the years of great abundance of the beetles hogs should be turned into orchards and timber lots during the period of flight (May and June), since a majority of the beetles pass the day just below the surface of the soil beneath or near the trees upon which they have been feeding the night before, and will be eagerly sought and eaten by the hogs.

FALL PLOWING.

Where it is impracticable to pasture hogs in an infested field much good can be accomplished by plowing the land in the fall. The plowing should be done late in fall, but, on the other hand, it should not be delayed until cold weather sets in or until the ground becomes chilled and frosty, for then the grubs will have gone down to their

[1] *Echinorhynchus gigas.*

[2] Forbes, S. A. On the life history, habits, and economic relations of the white grubs and May beetles (Lachnosterna). Ill. Agr. Exp. Sta., Bul. 116, p. 479, August, 1907.

winter quarters beyond the reach of the plow. Ordinarily the best time to plow is between October 1 and October 15. *In 1913 deep plowing at any time in the fall, especially in early fall, will be of special value in those regions where the grubs were so destructive in 1912, since the grubs will then have changed to pupæ and adult beetles, and these will be destroyed if the pupal cells in which they pass the winter are disturbed.*

ROTATION OF CROPS.

Since the beetles usually deposit their eggs in fields of grass, timothy, and small grains, the crops planted in these fields the year following a season of beetle abundance should be those which are the least susceptible to grub injury, such as small grains, buckwheat, clover, alfalfa, and peas. Care should always be exercised in the selection of a crop to follow sod or old timothy ground, even though the beetles were not noticed as especially abundant the preceding year. Where hogs can be pastured on the land the fall or spring previous to planting, as discussed in another paragraph, the grubs will be practically eliminated.

COLLECTING THE GRUBS AND BEETLES.

Where it is possible to secure cheap labor, collecting the grubs after the plow is practicable, especially where the grubs are numerous. In Europe children are often employed to gather grubs in this manner and to collect the beetles as described below.

Collecting the cockchafer or Maikäfer, a beetle very closely related to the May beetle, is a common practice in European countries, but so far as known the attempt to collect May beetles on an extensive scale in the United States has never been made. Three methods may be employed in beetle destruction: (1) Collecting from plants upon which they feed at night, (2) trapping at lights, and (3) poisoning their food plants.

In Europe beetle collecting has proved of value largely because the years of abundance of the beetles have been definitely known in advance, while in America this has not been the case. Now, however, there is proof that the beetles occurring in such abundance in many parts of the United States in 1911 (the parents of the destructive generation of grubs in 1912) have a life cycle of three years, and it is reasonably certain that they will continue to be exceptionally abundant in these regions every three years unless killed off by their natural enemies, by artificial means, or by unfavorable climatic conditions. Beetle collecting in the Old World has also proved practicable, first, because of the organized cooperative movement by the farmers for the collection of the beetles; second, because a small bounty is paid for the beetles; and, third, because of laws which in some countries require each farmer to collect a certain quantity of the grubs or beetles each year. Individual action is useless, and only

where whole communities or neighborhoods cooperate in the work is it effective.

In collecting from food plants large cloth sheets are placed under the tree and the latter jarred, or in the case of large trees individual branches may be shaken by using a long pole provided with a hook at the end. The beetles are then gathered up from the sheet and placed in cans, bottles, or boxes and afterwards killed with carbon bisulphid. Killed in this manner they may be fed to chickens, pigs, etc., but if they are not to be used for such purposes they may be killed by dropping them in cans containing water and just enough kerosene oil to cover the surface. Different species have different food preferences, but as a rule beetles are most abundant on the oak, walnut, poplar, hackberry, willow, ash, and elm. Collections may be made at any time during the night, but the best time for this work is in the early morning, before 4.30 o'clock, at a time when the beetles are easily jarred from the foliage. It is essential that collecting be begun as soon as the beetles appear in the spring—that is, before the beetles have begun to lay their eggs—and it should also be borne in mind that each female beetle destroyed early in the season means the destruction of from 50 to 100 grubs which she might have produced.

Light traps have not as yet proven satisfactory as a means of control against May beetles, the prime objection to this method being that the light attracts the males to the almost total exclusion of the females. Further tests with this method must be made, and it is possible that the light may prove attractive to the female beetles in years of unusual abundance if placed close to the trees or shrubs upon which they feed.

SPRAYING.

Spraying trees upon which the beetles feed, with Paris green or arsenate of lead, is effective against the beetles, but ordinarily this method is impracticable owing to the large size of the trees, which would necessitate large and expensive power sprayers. With a more definite knowledge of the preferred food plants, it may be found practicable in some localities to plant low-growing trees and shrubs about fields as traps for the beetles, which might then be destroyed by spraying.

SPECIAL DIRECTIONS.

In those regions in which the grubs were so abundant and destructive in 1912 certain special directions and precautions may prevent a repetition of the damage in 1915. As has already been stated, the parents of the grubs of 1912 appeared in the spring of 1911 and laid the eggs which hatched into the grubs. Practically no damage occurred that year, but in 1912, when about half grown, the grubs caused great loss. These grubs will continue active in the spring of 1913 and may injure certain early plantings, but by early June most of the grubs will have become more or less inactive and later

will change to the dormant or pupal stage, transforming to beetles about August. They will remain in the soil as beetles over winter, appearing above ground in the spring of 1914. Small grain may, with comparatively safety, be planted in 1913 on land infested in 1912. If infested ground must be utilized for corn, potatoes, or other susceptible crops in 1913, planting should be delayed as long as possible, in which case injury will be minimized or may be wholly prevented. In 1914 a maximum acreage of such crops as corn and potatoes should be planted, and these should be kept thoroughly cultivated during the flight of the beetles. Land which is planted to small grain, timothy, and other crops which cover the ground with vegetation at the time of the flight of beetles should be planted in fields farthest from trees, and such fields should be planted the following year (1915) to crops least susceptible to white-grub injury, such as clover, alfalfa, small grains, and buckwheat. In addition, the methods which have already been discussed, namely, the use of hogs and domestic fowls, fall plowing, and the gathering of beetles and grubs, should be practiced.

IN THE LAWN.

No reliable remedy can be offered for the destruction of grubs in lawns. Where possible, poultry, especially turkeys, should be allowed the run of the infested area. Hogs will of course rid the ground of grubs, but they will likewise tear up the sod and are not usually desirable in cities. When badly infested, the removal of sod and the gathering of the grubs by hand, and later, fall plowing, will probably prove satisfactory. If the infestation is not severe, liberal applications of commercial fertilizer will assist the grass in overcoming the grub injury. It has been demonstrated in Europe by Decoppet [1] that carbon bisulphid injected into the soil at a depth not exceeding 6 inches, at the rate of 1 to 1½ ounces in six or eight holes per square yard, will considerably diminish the number of grubs. Decoppet experimented with an European white grub,[2] and it appears quite probable that this method would prove satisfactory for our white grubs when they appear in lawns. It might be mentioned here that carbon bisulphid may be injected with excellent results into the holes of the grub of the southern green June beetle, which is frequently quite destructive to lawns in the Southern States. In using carbon bisulphid care should be exercised never to permit a spark of fire to come near it, for it is extremely inflammable, and its vapor, mixed with air, is explosive. Holes in which the carbon bisulphid is injected should be closed with a plug of soil or sod immediately after the injection, to prevent the escape of the fumes.

[1] Bul. Soc. Vaud. Sci. Nat., 5me ser., t. 48, no. 176, pp. xxxv–xxxvi, June, 1912. Abstr. in Internat. Inst. Agr. (Rome), Bul. Bur. Agr. Intel. and Plant Diseases, vol. 3, no. 6, pp. 1456–1457, 1912, and in U. S. Dept. Agr., Experiment Station Record, vol. 27, no. 7, pp. 661–662, 1912.

[2] *Melolontha* sp.